JANUARY 3, 2004 PAGES 1-16 VOL. 165, NO. 1

SCIENCE NEWS

THE WEEKLY NEWSMAGAZINE OF SCIENCE

voyager's outer passage
new quirks for quarks
chilean blue whale nursery
oldest primate discovered

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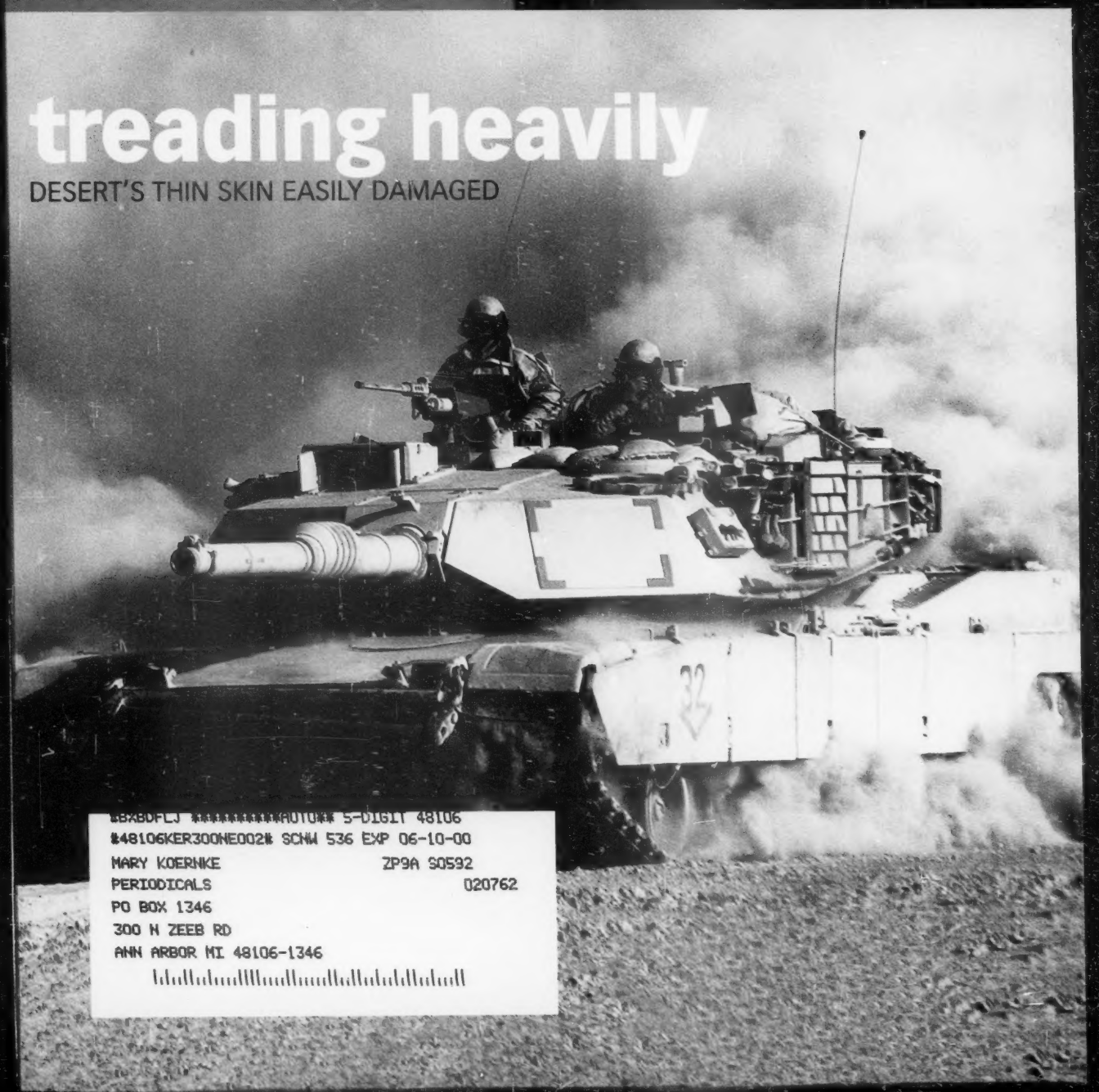
treading heavily

DESERT'S THIN SKIN EASILY DAMAGED



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Cover As vehicles such as this tank rolled across Iraq last March, they often disrupted a thin crust of stones known as desert pavement and exposed the dusty material beneath to the wind's erosive forces. Scientists are now devising experiments to test various restoration schemes. (Scott Nelson/Getty Images) Page 11

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Topsy Turvy

In neutrons and protons, quarks take wrong turns

Physicists peering inside the neutron are seeing glimmers of what appears to be an impossible situation. The vexing findings pertain to quarks, which are the main components of neutrons and protons. The quarks, in essence, spin like tops, as do the neutrons and protons themselves.

Now, experimenters at the Thomas Jefferson National Accelerator Facility in Newport News, Va., have found hints that a single quark can briefly hog most of the energy residing in a neutron, yet spin in the direction opposite to that of the neutron itself.

"That's very disturbing," comments theoretical physicist Xiangdong Ji of the University of Maryland at College Park.

The finding suggests that scientists may have erred in calculations using fundamental theory to predict quark behavior within neutrons, he says. It might also indicate that orbital motions of particles within neutrons, in addition to those particles' spins, are more important than previously recognized. Those motions might be akin to the moon's rotation around Earth as the satellite also spins about its own axis.

Given that neutrons and protons are sister particles, called nucleons, the new findings apply to both, says Xiaochao Zheng, a member of the experimental team who's now at Argonne (Ill.) National Laboratory.

Nucleons are the building blocks of atomic nuclei. A typical nucleon includes three quarks: two down quarks and one up quark for a neutron; two up quarks and one down quark for a proton. In addition to those so-called valence quarks, each nucleon contains multitudes of gluons—particles that bind quarks —and of short-lived quark-antiquark pairs, known collectively as the quark sea.

Each of these constituents of a nucleon carries some share of the nucleon's energy, although the distribution of that energy among the constituents constantly shifts, Ji explains.

From previous experiments, scientists knew that only valence quarks can grab major portions of a nucleon's total energy content, says Jian-Ping Chen of the Jefferson lab, a coleader of the experiment. The new spin-detecting experiment is the first to measure the state of the neutron when most of its energy momentarily resides in a single quark.

Calculations based on the prevailing theory of quark behavior predict that any quark holding more than about half the energy of a nucleon should spin in the same direction as the nucleon. However, when the new experiment probed valence quarks temporarily laden with up to 60 percent of a neutron's energy, it revealed that only the up quarks behaved as expected. The down quarks somehow carried most of the energy yet rotated in a direction opposite to that of the neutron as a whole.

Electrons and entire atoms also have spins. To arrive at the new findings, the experimenters made a target of helium gas in which nearly all atoms were forced to spin in the same direction and bombarded it with a beam of high-energy electrons, whose spins were also forced to have uniform orientations.

The researchers determined the spin orientations of the quarks in the helium atoms by placing detectors in specific positions where they are more likely to make detections when the orientations of the electron's spin and the quark's spin are opposite, Zheng says. She and her colleagues present their results in an upcoming *Physical Review Letters*.

Since the late 1980s, experiments have revealed that no more than 20 to 30 percent of a nucleon's spin comes from the spin of its valence quarks. Physicists have been struggling to identify which of the nucleon's other constituents contribute to nucleon spin and how much—a puzzle known as the proton-spin crisis (*SN: 9/6/97, p. 158*).

These long-awaited neutron-spin data indicate that, under some conditions, the previously overlooked orbital motions of valence quarks make a major contribution to nucleon spin, comments theorist Gerald A. Miller of the University of Washington in Seattle. —P. WEISS

Whale Haunt

Nursing, feeding spot found off south Chile

A systematic survey has discovered a hangout for blue whales in the Gulf of Corcovado, an inlet of the Pacific Ocean between the southern Chilean mainland and the largest of the Chilean Islands. Last year, 47 blue whale groups, some including mothers and youngsters, were sighted in that area.

In the first 60 years of the 20th century, commercial whaling wiped out 97 percent of the Southern Hemisphere's blue whales, note Rodrigo Hucke-Gaete of the Southern University of Chile in Valdivia and his survey team. As of 2000, the International Whaling Commission (IWC) estimated that 700 to 1,400 blue whales remain in the Southern Hemisphere. Observations that can be made at the new, midlatitude site should fill in some knowledge gaps and help refine conservation efforts, Hucke-Gaete and his colleagues say in an upcoming *Proceedings of the Royal Society of London B: Biology Letters*.

"It's an exciting discovery," says another blue whale researcher, Bruce Mate of Oregon State University in Newport. Usually, blue whales are sighted near the poles or at the equator. In the Northern Hemisphere, scientists have found some blue whales that fre-

NOAA

BIG MYSTERY As large as blue whales are, the oceans are a lot larger, and biologists are still mapping out migration routes and feeding grounds for these hard-to-find creatures.

quent midlatitude spots. But in the Southern Hemisphere, a midlatitude location was "unexpected," says Mate.

Whaling records from 1907 and 1909 describe abundant blue whales in the area. An IWC survey in the late 1990s turned up a modest number of blue whales along the Chilean coast. But when several members of that survey team subsequently went on a sightseeing cruise in the area, they saw more blue whales than they had observed during months of official whale counting, says Mate.

Following up those serendipitous sightings, the new project systematically searched the Gulf of Corcovado region with five plane flights and two boat trips during the austral summer months of January to April 2003. Overall, the team made 153 sightings of blue whales, including 11 mother-calf pairs. The researchers' technique didn't always identify individual whales, so some were probably counted more than once.

On the basis of the behaviors that the researchers observed and the young ages of the calves, Hucke-Gaete and his colleagues classified the area as a feeding and nursing site. Mate cautions that neither the recently recognized area nor any other spot on the globe has been definitely shown to be a blue whale calving ground. The young whales stay with their mothers for about a year.

Mate adds that although the new population isn't large, its genetics may differ from that of whales observed at Antarctica.

Blue whales are protected from outright hunting worldwide, but accidental boat collisions and other clashes with people take their toll. Mate says that he hopes the Chilean government will find ways to make the newly recognized feeding grounds a safe haven for blue whales. —S. MILIUS

My Own Private Bad-Air Day

Outdoor data underrate pollutant exposure

A new study suggests that most people inhale substantially more organic contaminants, including cancer-causing benzene, than is indicated by standard environmental risk assessments based on outdoor measurements.

"Ambient measurements at central sites aren't good predictors of [personal] exposure," says John Adgate of the University of Minnesota in Minneapolis. "Actual exposures are higher."

SELF-DISSERVICE **Activities such as refueling a car expose people to contaminant-laden air.**

To monitor urban air quality, environmental agencies typically measure pollutant concentrations in samples collected at centralized outdoor locations and extrapolate individuals' average exposures from those measurements. That's a reasonable approach for studying ozone and other pollutants that form out-of-doors or that come almost exclusively from identifiable industrial sources.

But for volatile organic compounds (VOCs), which arise from sources such as air fresheners, cleaning agents, and cigarette smoke, assessments of outdoor air quality misrepresent what's under people's noses, researchers now report. That's because many daily activities—including driving to work, visiting dry-cleaning shops, and sitting in smoky restaurants—put people in envelopes of air that are disproportionately laden with chemicals.

Adgate and his colleagues outfitted 71 nonsmoking volunteers in Minneapolis and neighboring St. Paul with lapel-mounted air filters that sopped up VOCs for 2 days. In the lab, the team then used gas chromatography to measure 15 specific VOCs. The researchers simultaneously sampled VOCs from a central location inside each volunteer's home and from a nearby exterior location.

For 14 of the VOCs, all of which are designated as hazardous by the Clean Air Act, the lapel sensors contained much higher concentrations than outdoor samples did. Indoor measurements tended to be intermediate. According to the lapel sensors, the median personal exposure to benzene was 3.2 micrograms per cubic meter, whereas outdoor and indoor concentrations were 1.3 $\mu g/m^3$ and 1.9 $\mu g/m^3$, respectively. Lifelong exposure to 1.3 $\mu g/m^3$ of benzene in air is considered enough to cause 10 cancers in a million people, whereas 3.2 $\mu g/m^3$ would correspond to 25 cancers.

Outdoor and indoor benzene concentrations have fallen in recent years, a result of declines in cigarette smoking and of regulations that permit less benzene in gasoline and consumer products, says Lance Wallace of the Environmental Protection Agency in Reston, Va. Nevertheless, he adds, the new study suggests that nonsmokers' personal exposures are surprisingly high.

Among the VOCs that Adgate and his team studied were chloroform, a by-product of chlorination that's released from household water; *d*-limonene and *a*- and *b*-pinene, common deodorizing chemicals that produce scents of lemon and pine; para-dichlorobenzene, an air freshener and pesticide; and tetrachloroethylene, which emanates from dry-cleaned clothing. Median concentrations of these compounds in personal air ranged from about 3 times to nearly 60 times those found in outdoor air, the researchers report in an upcoming *Environmental Science and Technology*.

Fortunately, says Wallace, "it's easy . . . to do something about it." Excess personal exposure can be minimized by avoiding cigarette smoke, air fresheners, and long automobile commutes and by using cleaning agents and other chemicals only in well-ventilated areas. —B. HARDER

Ancestral Handful

Tiny skull puts Asia at root of primate tree

Researchers have unearthed the partial skull of the oldest known primate, a teeny creature that lived in south-central China 55 million years ago.

The discovery extends the geographic reach of the ancient genus *Teilhardina* into

Asia, say Xijun Ni of the Chinese Academy of Sciences in Beijing and his coworkers. Until now, all *Teilhardina* fossils had been teeth and jaw fragments from North America and Europe.

Teilhardina belonged to the tarsierlike omomyids that lived 55 to 36 million years ago. They were precursors of today's tarsiers, monkeys, apes, and people.

The newly found fossil derived from an animal that was smaller than any living primate. Weighing about 1 ounce, it would have fit in the palm of a person's hand. The creature's size and sharp teeth peg it as an insect eater, the scientists report in the Jan. 1 *Nature*.

The fossil's forward-looking eye sockets are also revealing: They're much smaller relative to skull length than those of any other omomyid specimen. Living primates with small, forward-facing eyes are generally diurnal, staying active during the day and sleeping at night. This raises the surprising possibility that *Teilhardina* originated in Asia as a diurnal primate, but that its descendants evolved into large-eyed, nocturnal animals.

"That's not at all what I expected," remarks paleontologist Richard F. Kay of Duke University Medical Center in Durham, N.C. The finding suggests that the first primate ancestor may have been diurnal, too, he says.

K. Christopher Beard of the Carnegie Museum of Natural History in Pittsburgh, who specializes in Asian primate fossils, calls the new find a "landmark discovery." It shows that ancient primate evolution proceeded with twists, rather than in a straight line, toward apes and people, he says.

Or maybe not. Although the Asian *Teilhardina* find comes from a primate that lived near the time of omomyid origins, this ancient creature could have been nocturnal, as has been traditionally assumed, says paleontologist Robert D. Martin of the Field Museum in Chicago in a commentary published with the new report. In particular, he notes, the fossil contains a large opening on the snout to accommodate a nerve for the whiskers. Such a large opening is common among nocturnal mammals.

The Asian find casts doubt on the argument that 55-million-year-old fossils recently found in Wyoming came from a close primate relative of the ancestor of modern monkeys, apes, and humans (*SN: 12/21&28/02, p. 399*). This genus, *Carpolestes*, differed substantially from *Teilhardina*. The North American creature had relatively large, side-facing eyes and ate primarily fruit. Kay suspects that *Carpolestes* actually belonged to a line of nonprimates that evolved some primatelike features.

The new find supports the theory that ancient *Teilhardina* species migrated back and forth between Asia and Europe 55 million years ago, at a time when waterways from the north and south split Eurasia vertically down the middle, Martin adds.

In contrast, Beard theorizes that *Teilhardina* migrated from Asia across land bridges to North America and then to Europe. Africa became central to primate evolution only after this intercontinental trek, he contends.

Kay doesn't discount Africa as the place where primates first arose. "But the fossil evidence for Asia is growing," he says. —B. BOWER

Blasts from the Past

Orbiting radar spots old nuclear-test sites

Satellite analysis can reveal sites of past underground nuclear tests, U.S. government scientists report. The technique can detect the settling of ground above blasts that occurred decades ago, before current monitoring networks were established.

VINCENT ET AL.

SINKING FEELING Ground subsidence around the Nevada Test Site's Junction cluster (arrow) of underground nuclear tests (asterisks) shows up on InSAR images as fringes of pink and yellow.

Underground nuclear tests are restricted by the 1996 Comprehensive Nuclear Test Ban Treaty, which 170 nations have signed and 108 have ratified. The typical hallmarks of underground blasts—increases in radiation and telltale vibrations in Earth's crust, atmosphere, or oceans (*SN: 7/14/01, p. 25*)—reveal nuclear explosions as they happen or soon after. The new radar-analysis technique, however, can identify the locations of long-ago tests, possibly revealing a nation's unconfirmed nuclear capability. In the future, it might be used to supplement the international monitoring network of sensors.

Interferometric synthetic aperture radar (InSAR) combines data from images taken from the same point in space at two different times. Analysts can discern intervening horizontal or vertical movements of Earth's surface as small as 1 centimeter, says Paul Vincent, a geophysicist at the Lawrence Livermore (Calif.) National Laboratory. Scientists have used the technique to detect the fall and rise of the ground's surface as cities pump water from and into aquifers (*SN: 8/25/01, p. 119*) and to discover ice-bound islands (*SN: 4/6/02, p. 222*).

In their new research, Vincent and his colleagues analyzed ground movements at the Nevada Test Site, a 3,500-square-kilometer facility 100 km northwest of Las Vegas. Scientists conducted nuclear tests there between 1951 and 1992.

InSAR images of the facility's Pahute Mesa site show a 2-km-long elliptical area where the ground sank about 8 cm between April 1992 and June 1993, the dates of the satellite images analyzed. That bull's-eye marks the spot where five underground nuclear tests—including a March 1992 blast code-named Junction—took place. The analysis detected continuing subsidence in ground over the sites of tests conducted in the late 1960s, more than 2 decades before the launch of the commercial satellite that makes today's InSAR images, Vincent says. His team reports its findings in the Nov. 15, 2003 *Geophysical Research Letters*.

Subsidence at the Pahute Mesa site shows up far beyond the edges of some craters caused by blasts, says Vincent. The peripheral deformations probably come from the gradual settling of rock pulverized by the blasts. Water filtering through the ground might have dissolved some of the cracked rocks' rough edges, permitting the ground to settle. Also, later underground blasts nearby jostled the rocks and triggered subsidence.

InSAR is a "promising technique" for finding the sites of underground nuclear tests, says William S. Leith of the U.S. Geological Survey in Reston, Va. Some test sites used by China, France, the former Soviet Union, and some other countries don't show obvious collapse craters, he notes. However, all blasts, regardless of the terrain where they occur, probably leave some surface signs, says Leith. The trick, he adds, will be figuring out how to interpret those hallmarks. —S. PERKINS

Pivotal Protein

Inhibiting immune compound slows sepsis

By restraining the action of an immune system protein that can run amok, scientists experimenting on mice have reversed the course of severe sepsis, an often-lethal blood infection that shuts

down vital organs. The work suggests that neutralizing this protein would halt the disease in some people, but researchers acknowledge that a human trial is still years away.

Sepsis arises as a complication of pneumonia, appendicitis, burns, infections, trauma, or other factors. Cell damage, either by microbial toxins or injury, sets off the immune reaction that leads to severe sepsis. As the body lurches into a self-defense mode, it mass-produces inflammatory proteins, such as tumor necrosis factor alpha (TNF-alpha) and high-mobility group box 1 (HMGB1).

Some patients die when their blood pressure crashes and organs fail, a combination of phenomena known as septic shock. This inflammatory spiral is orchestrated by TNF-alpha, says Kevin J. Tracey, a neurosurgeon at North Shore–Long Island Jewish Research Institute in Manhasset, N.Y.

However, many people who die from severe sepsis have few signs of inflammation in their tissues, autopsy data show. Tracey suspected that HMGB1 is the major culprit in such patients. In earlier work, he and his team had found that HMBG1 undermines the linings of body cavities, such as the abdomen, making them leaky. The chemical imbalance that results probably leads to organ failure, he says.

Tracey and his colleagues recently tested two anti-HMGB1 agents in mice with severe sepsis. The researchers had induced the condition by perforating the large intestines of 36 mice. Twenty-four hours later, they gave half the animals antibodies against HMGB1, and the other mice received unrelated antibodies. After 2 weeks, 13 of the mice getting anti-HMGB1 treatment had survived, compared with only 5 of the others. Giving an HMGB1-inhibiting drug called A-box achieved similar results in another batch of mice, the researchers report in the Jan. 6 *Proceedings of the National Academy of Sciences*.

In severe sepsis, dying cells release compounds that attract immune cells called macrophages, which then produce HMGB1. Anti-HMGB1 antibodies act by surrounding HMGB1 molecules, keeping them from binding to healthy cells. The A-box compound works by stalling HMGB1 production in macrophages.

The new study "underscores the potential of HMGB1 as a therapeutic target in the future treatment of sepsis," says Mark Perrella, a pulmonologist at Harvard Medical School and Brigham and Women's Hospital in Boston. But Perrella notes that sepsis is an unpredictable disease. While HMGB1 is apparently the problem in some patients, death occurs in others because anti-inflammatory proteins compromise immunity and leave a person vulnerable to further infection. Eventually, doctors might use genetic profiling to choose the best anti-sepsis therapy, Perrella says.

Doctors might also determine a patient's immune status by measuring HMGB1 concentrations in the blood, Tracey notes. —N. SEPPA

Gene Screen

Ultrasensitive nanowires catch mutations

In the nanoworld, the division between wet biology and dry electronics can disappear. As a demonstration, researchers have devised a nanowire sensor that binds to DNA molecules and produces an electrical signal almost instantaneously. Such direct detection of DNA could enable physicians to use a single drop of blood to swiftly screen patients for myriad genetic disorders.

The sensor, developed by chemist Charles Lieber of Harvard University and Jong-in Hahm, now of the Pennsylvania State University in State College, consists of a silicon wire several microns long and 20 nanometers wide. That's the width of a common cold virus. The small-scale system detects a genetic mutation that underlies cystic fibrosis, a lung-clogging disorder that affects about 30,000 people in the United States.

To detect the mutation, the researchers placed the wires on a silicon surface and fixed an electrode to each of the wires' ends. They then coated the wires with receptors harboring fragments of DNA that are complementary to the normal sequence of the gene implicated in cystic fibrosis.

When a sample containing DNA passed over the nanowire, the relevant DNA bound to the receptor and the nanowire's conductivity increased. Normal DNA formed tight bonds with the receptor DNA, boosting the nanowire's conductivity dramatically. Mutant DNA, on the other hand, bound to the receptor only loosely, resulting in a much smaller increase in conductivity. Lieber and Hahm describe their results in the Jan. 14 *Nano Letters*.

Not only can the nanowires respond to a gene within seconds, but they also generate measurable signals from just a few DNA molecules, says Hahm.

Existing genetic-screening technologies are more cumbersome. To obtain a strong signal, clinicians have to extract DNA from cells, produce many copies of it, label it with fluorescent tags, and then measure the fluorescence after it binds to detectors. The new nanowire skirts those time-consuming steps.

"What's also great about this technique is its versatility," says Hahm. In the cystic fibrosis demonstration, the nanowires detected a particular gene mutation that accounts for 70 percent of the disease's cases. Scientists have identified hundreds of additional mutations in this same gene that appear to underlie the remaining 30 percent of cases. With the new biosensor method, researchers could pack a chip with hundreds of wires—each tailored to a specific mutation—and hook them up to arrays of electrodes so that their individual signals could be read out. Such a device could detect all the cystic fibrosis mutations simultaneously from a single blood sample.

Because the nanowires are so tiny, researchers could eventually pack millions of them onto a chip and rapidly test a blood sample for all the known genetic mutations in the human genome. The sensor could do this at a fraction of the cost of current genetic screens, says Hahm.

"What's exciting here is that the researchers expanded the capability of the nanowires to detect DNA," says Yi Cui, a chemist at the University of California, Berkeley. The same silicon nanowires used to make these DNA sensors have been used by Lieber's team to make nanoscale transistors for computing devices.

Compared with complex computer circuitry, Lieber says, the DNA sensors "are probably one of the most realistic near-term applications of nanoscience." —A. GOHO

ELECTRIC MATCH When receptors on a silicon nanowire (top) bind to DNA, the resulting complex (bottom) increases the wire's conductivity.

LIEBER

NEXT STOP, INTERSTELLAR SPACE

Voyager journeys to the edge of the solar system

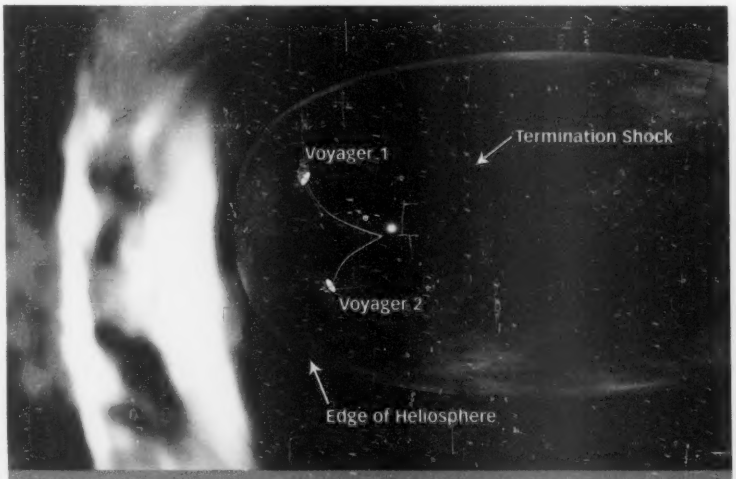
BY RON COWEN

On the interplanetary highway, there are no mile markers and no exit signs. Precious few clues indicate that you're nearing the edge of the solar system. Those clues, however, are revealing that the venerable Voyager 1 spacecraft, launched 26 years ago and now 90 times as far from the sun as Earth is, either has reached or will soon enter a turbulent region near the solar system's final frontier. There, the solar wind first slams into large numbers of atoms and molecules that have leaked into the solar system from interstellar space. The encounter puts the brakes on the solar wind, causing it to abruptly slow from supersonic speeds of 400 to 700 kilometers per second down to subsonic speeds of 100 km/sec, according to simulations.

Signals that the elderly spacecraft recently radioed to Earth indicate that it might have already encountered this bizarre region, known as the termination shock. If so, it would be the first time that a human-made object has reached that milestone, notes Stamatios (Tom) Krimigis of the John Hopkins Applied Physics Laboratory in Laurel, Md. The craft would then be on course to exit the solar system.

The solar system's outer boundary, which lies beyond the termination shock, is the edge of the heliosphere, the vast bubble of space filled by the wind of charged particles continuously blown by the sun. Contracting or expanding as the solar wind blows slower or faster, the heliosphere generously envelops all the planets. The radius of the heliosphere is more than three times that of Pluto's orbit. It will take Voyager 1 another 15 years or so to burst out of the bubble and begin exploring interstellar space.

Recent data from the spacecraft may be revealing previously unknown and complex features of the outer solar system, says Len A. Fisk of the University of Michigan in Ann Arbor. Information about the termination shock may also provide insight into the more powerful shocks generated by supernova explosions.



ON THE EDGE — Artist's conception of location of the two Voyager spacecraft within the vast bubble of charged particles known as the heliosphere. This bubble, blown out by the solar wind, defines the extent of the solar system. The bubble contracts or expands as the solar wind varies in strength. The termination shock (purple) marks the region where the solar wind is slowed abruptly by pressure from gas between the stars.

W. FEIMER/NASA

FRINGE SCIENCE Launched in 1977, Voyager 1 took some spectacular images of the outer planets. As it journeyed billions of kilometers from Earth, through the outer reaches of the solar system, the information that Voyager relayed about the solar wind and energetic charged particles carried by the wind held no surprises. But for a 6-month period beginning in August 2002, the craft radioed data that didn't resemble any that planetary scientists had seen before.

One of the craft's detectors recorded a 100-fold surge in the intensity of certain charged particles—electrons greater than 350,000 electron volts and protons ranging in energy from 40,000 eV to more than 70 million eV. The particles were also moving in a different direction than were those the craft had recorded during the previous 25 years. Instead of riding the solar wind on an outbound trajectory, these particles were moving perpendicular to that direction.

For these changes to occur, "something must have happened to the solar wind," says Krimigis.

Those changes dovetail with other data that Krimigis rates as the clearest, albeit indirect, evidence that Voyager 1 had entered the termination shock. Voyager 1's solar-wind monitor stopped working in 1980, so scientists couldn't directly determine whether the solar wind had slowed. Krimigis and his colleagues did the next-best thing. They estimated the wind's speed by using the spacecraft's charged-particle detector, which can measure the populations and directions of electrons and ions.

The detector is mounted on a motorized rotating platform—still powered by the spacecraft's nuclear batteries—that enables it to record information about the particles arriving from all directions. Krimigis and his coworkers compared the readings taken when the detector was facing the solar wind with ones taken when

Continued on page 10

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—Dean Rieck,
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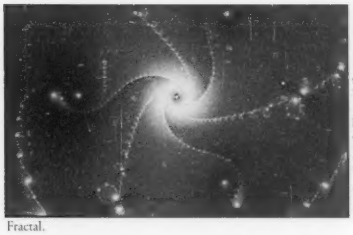

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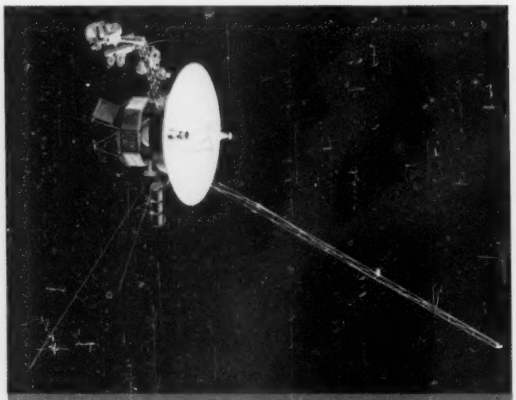
Continued from page 7

the detector was looking outward into deep space. The detector had always recorded substantially more particles in the wind-facing direction. That's just what would be expected when the wind, which boosts the movement of the charged particles, blows at high speeds. But beginning in August 2002 and continuing through January 2003, the detector recorded about equal numbers of particles in both directions.

Krimigis and his colleagues say that's strong evidence that Voyager 1 had entered a region in which the solar wind was moving much more slowly than it does in more-inward parts of the solar system.

In the Nov. 6, 2003 *Nature*, the team cites another telling piece of evidence that Voyager 1 had reached the termination shock. From August 2002 through January 2003, the relative abundances of hydrogen, helium, carbon, and oxygen ions recorded by Voyager 1 differed from all previous measurements. They no longer resembled the mix of ions found in interplanetary space within the solar system but instead mirrored the composition expected for interstellar atoms.

The data suggest that for 6 months, Voyager 1 was inside the termination shock, says Krimigis. His team conjectures that sometime in January 2003, a chance increase in pressure from the solar wind pushed the termination shock outward, leaving the spacecraft behind.



INTREPID TRAVELER — Artist's depiction of the Voyager 1 spacecraft, which is nearing the edge of the solar system.

NASA

EDGY CONTROVERSY In the same issue of *Nature*, however, Frank B. McDonald of the University of Maryland in College Park and his colleagues rely on different Voyager 1 data to argue that the craft hasn't yet reached the shock region but may cross it shortly.

At the termination shock, McDonald notes, charged particles are accelerated to 1,000 times their initial energy, creating a group of energetic particles known as anomalous cosmic rays. A detector on Voyager 1 recorded an increase in intensity of these cosmic rays from August 2002 through January 2003, but the spike was nowhere as large as would be expected for a craft within the termination shock region, McDonald notes. As he sees it, the slight rise in cosmic ray intensity indicates that the spacecraft is approaching the shock region but is not quite there.

Bolstering that view, simple models of the heliosphere require that the magnetic field intensifies in regions where the solar wind slows. In the Oct. 30, 2003 *Geophysical Research Letters*, Leonard F. Burlaga of NASA's Goddard Space Flight Center in Greenbelt, Md., and his colleagues report that Voyager 1 didn't detect a rise in the magnetic field.

McDonald and Krimigis have been arguing about their data since last April, when Krimigis presented his findings in Nice, France, at a joint meeting of the European Geophysical Society, the American Geophysical Union, and the European Union of Geosciences. "Perhaps he had too much French wine to drink," McDonald says with a chuckle.

Notes astrophysicist Fisk, who studies the solar wind: "There's no question that the sets of data are in conflict." But that's where things start to get interesting, he adds.

"Maybe the termination shock is not what would be expected . . . from the simplest models," he says. "Assuming everyone did their job correctly [analyzing the Voyager 1 data], you may have to make up a new complex model to reconcile all these data sets."

Fisk notes that in more-complex models the magnetic field at the termination shock may not be significantly greater than in more central parts of the solar system.

Fisk also suggests that the termination shock may have a ragged shape. Instead of being a perfectly spherical shell, the termination-shock region has inwardly directed protrusions of material, he speculates. If Voyager 1 passed through one of these protrusions, it might show a decrease in the speed of the solar wind, just as the detector used by Krimigis' team indicated. Because the bulk of the termination shock would still have been quite a distance away, however, the spacecraft wouldn't have encountered a large upturn in the abundance of anomalous cosmic rays. That scenario is consistent with McDonald's finding.

"We may have to rethink how [anomalous] cosmic rays are accelerated," says Fisk. He notes that the termination shock is the closest known analog to the supernova shock wave generated when material hurled from an exploded star rams into the low-density region of space surrounding it.

"If the termination shock is more complex than we had thought, this may have direct application to supernova shock waves," says Fisk.

FUTURE SHOCK Scientists won't have to wait long for direct observations of the termination shock. If Voyager 1 hasn't entered that region yet, it is expected to do so within the next few years and beam clear-cut evidence back to Earth, says McDonald.

If the craft at that time is merely catching up with the termination shock that it had already encountered, the new data ought to be identical to those recorded in August 2002, notes Krimigis.

But there's an even simpler test. The Voyager 2 spacecraft is also heading out to the solar system's edge. Some 29 million km farther from that edge than Voyager 1 is, Voyager 2 has a working solar-wind-speed detector. A few years from now, that detector is expected to provide unequivocal proof that Voyager 2 is passing through the termination shock, says Fisk.

The ultimate milestone remains the exit from the solar system into the vastness of interstellar space, and researchers now have new information about exactly where that edge lies. Guided by strong bursts of radio waves that Voyager 1 has detected since November 2002, scientists now calculate that the edge, known as the heliopause, resides between 153 and 158 times as far as Earth does from the sun.

The bursts were probably generated when clouds of solar material, hurled by the sun during an unusually stormy period in April 2001, rammed into cold interstellar ions at the edge of the solar system, says Donald A. Gurnett of the University of Iowa in Iowa City. Radio bursts from that collision then traveled back toward the sun and were intercepted by Voyager 1. From the speed of the clouds and the time it took them to reach the heliopause, Gurnett's team calculated the distance to the edge. He reported the findings, which are consistent with his team's analysis of similar radio bursts recorded by Voyager 1 a decade ago (*SN: 5/29/93, p. 343*), last month at the fall meeting of the American Geophysical Union in San Francisco.

Trying to find the solar system's edge, Gurnett cautions, is a search for a moving target because its location depends on how strongly the solar wind is blowing. Nonetheless, the best estimate is that Voyager 1 could reach that border around 2020, just as the aging craft is expected to run out of power. Researchers will be anxious to learn whether Voyager 1 broadcasts its swan song to Earth or travels silently into the abyss. ■

THIN SKIN

Desert's fragile crust takes millennia to form but only moments to destroy

BY SID PERKINS

As they barreled across the desert toward Baghdad during the U.S.-led invasion of Iraq last March, the tanks, trucks, and armored personnel carriers churned up huge clouds of dust. Iraqi vehicles mobilized to defend against the onslaught generated their own plumes of grit. In a literal sense at least, much of the dust in Iraq has begun to settle. If history is a guide, however, the ruts the combat vehicles left behind will spew prodigious amounts of dust for years. That airborne material can cause major environmental and health problems.

As the battalions maneuvered across the arid terrain, their vehicles often broke through a delicate crust known as desert pavement. This type of veneer covers as much as half of the world's arid lands. Despite the connotations of its name, desert pavement isn't robust. It's merely a thin shell of stones that lies atop the dust, soil, or sand. Multiton tanks easily breach these fragile mosaics, but so do dirt bikes and all-terrain vehicles. Even trudging hikers, grazing animals, and the scrabbling of rodents and birds can disrupt desert pavements, exposing subsurface material to erosion and disrupting fragile ecosystems of fungi and algae.

DESERT DUST-UP — Military exercises in the Mojave Desert in the early 1940s, practice for World War II tank battles in northern Africa, left scars in desert pavements that are still visible today.

U.S. GEOLOGICAL SURVEY

Damage can happen in a moment, but the processes that sculpt desert pavement typically act slowly, taking centuries to generate a surface resistant to wind erosion. Therefore, when desert pavements and their biota are wounded by human activity, it will take human action to heal them on a shorter timescale.

Scientists are currently developing large-scale experiments to determine what methods might be most effective for mending a scarred desert. Successful techniques, far from being of interest only in war-torn regions, might also address a plague of problems that could result from an increase in the recreational use of environmentally sensitive public lands in the American Southwest.

BACK TO THE FUTURE In August 1990, Iraqi troops invaded and captured Kuwait. For the next 6 months, they dug pits in the desert to hide equipment, excavated trenches to protect soldiers, and built 2-meter-tall sand berms to slow opposing troops. Military maneuvers during the liberation of Kuwait in February 1991 scarred the desert further. A comparison of satellite images taken just before and after the conflict show that almost 950 square kilometers of desert pavement were destroyed by such activity, says Farouk El-Baz, a geologist at Boston University. The planting or removal of land mines denuded another 3,500 km^2 or so. In all, the desert pavement across more than 20 percent of Kuwait's land area was disrupted.

As a result, immense quantities of the area's fine-grained soil, previously locked beneath a stony blanket, were lofted by winds. Airborne dust reduced visibility and exacerbated a variety of health problems, such as asthma and other respiratory ailments, says El-Baz. Within months, the fine sands accumulated in dune fields on the northern shore of Kuwait Bay. In western portions of the country, sheets of sand smothered some roads and farms.

All that material had been brought to the area over the eons by the Tigris and Euphrates Rivers, says El-Baz. Water flow in the rivers decreased when the region's climate changed about 5,000 years ago and wind began to winnow the river delta's dried sediments. Dust and sand in the upper layers of sediment were blown elsewhere, but gravel and pebbles were left behind and eventually compacted into a thin armor against further wind erosion.

With today's drier climate in Kuwait and southern Iraq, it would probably take millennia for the wind alone to resculpt a fully mature desert pavement over the regions damaged by this year's conflict in Iraq, says El-Baz. Restoration of the landscape to its original flat contours would probably limit erosion, minimize health problems related to dust, and decrease the amount of time needed to regenerate the war-torn desert pavement, he notes.

However, El-Baz doesn't hold much hope for the war-torn soils of Iraq. "Everybody's thinking about the security of the soldiers there, and rightly so," he notes. "Nobody's even thinking about the security of the soil."

FLOATING ROCKS Although the initial phases of a desert pavement's formation are characterized by the wind-driven removal of surface dust and sand, other factors sculpt the rocky shell.

When the surface of nascent desert pavement becomes rough enough to interfere with airflow, small, windborne particles can drop out of that slow-moving boundary layer and fall between the

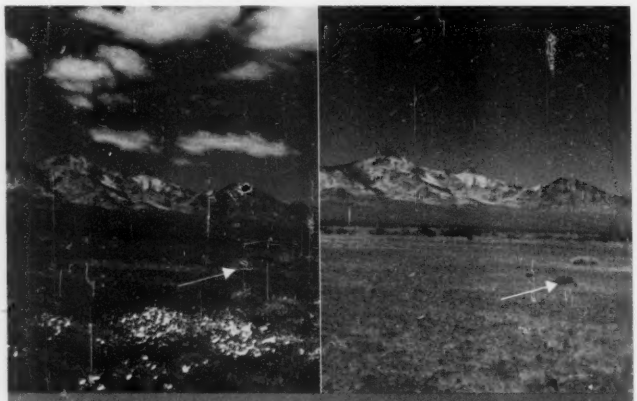
cracks of the pavement's stone mosaic. The trapped dust can even work its way underneath heavy pebbles, says Peter K. Haff, a geologist at Duke University in Durham, N.C. Any force that jostles surface pebbles—the impact of raindrops or the expansion and contraction of clay particles in the soil as they absorb and release moisture, for instance—can make the stones ride up on smaller particles that have recently fallen.

Even the footfalls of tiny animals can do the trick, says Haff. He once conducted an informal experiment in a terrarium on his desk, in which he placed a mixture of stones, pebbles, sand, and a few desert beetles large enough to budge marble-size stones as they propelled themselves across the ground.

Every few days, Haff scattered a little more sand in the terrarium. After a year, he'd added enough sand to create a layer 15 centimeters thick. The largest rocks remained buried at the bottom of the terrarium, and the smallest pebbles mixed throughout the sand. But a significant fraction of the medium-size stones—those measuring between 3 millimeters and 15 mm across—floated atop the steadily accumulating sand base.

Similar jostling of small stones across the surface of the ground can play a part in healing damaged desert pavements. In small-scale field experiments begun in 1983, Haff and his colleagues removed all surface stones from square patches of various sizes in the Mojave Desert. Over time, they noticed that surface pebbles 1 cm in diameter or smaller began to migrate into the vacant patches from surrounding areas. After a decade, the researchers' 10-cm-by-10-cm patches had repaved themselves, but the 20-cm and 40-cm plots weren't yet covered by the itinerant stones. Haff estimates that it would take 50 years for such pavementfree plots to mend.

That's a sluggish pace of renewal. If increasing human activity in these regions damages enough desert pavement, a plague of dust could result.



WET AND DRY — Most of the vegetation carpeting California's Greenwater Valley in April 1998 (left), nourished by El Niño rains, had disappeared by the next spring (right). Animals foraging for the seeds subsequently disrupted as much as 40 percent of the desert pavement in some areas of the valley. Arrow marks reference point.

TWO-TONE STONES Many rocks in arid areas sport desert varnish, a dark, shiny coating rich in iron oxides and manganese oxide. Although scientists debate how this natural glaze forms, they generally agree that the process takes a long time. Many petroglyphs left by ancient cultures were created when artists scraped away areas of dark desert varnish and exposed the lighter rock beneath. In some cases, desert varnish hasn't begun to form on the exposed rock, even though the petroglyphs were created millennia ago.

One testament to the age and stability of some desert pavements is the desert varnish that coats only the upward-facing exposed surfaces of the pebbles. While the rocks' sunny sides are dark and manganese rich, their ground-facing surfaces are often stained orange by iron oxides in the soil. That two-tone coloration enables scientists to recognize whether a desert pavement has been recently disturbed, says Haff.

In California's Greenwater Valley, just east of Death Valley National Park, much of the terrain is covered with a closely packed desert pavement that appears to have been undisturbed for centuries.

In April 1998, after the El Niño climate phenomenon steered above-average rainfall to Greenwater Valley, the normally barren desert pavement became carpeted with short grasses and wildflowers. The following April, after a climatically normal year, that living vegetation had nearly disappeared, Haff says. He also noted broad patches of pavement, ranging from small patches to areas half the size of a football field, where as many as 40 percent of the palm-size stones had been overturned to now sit orange-side up. Only 10 percent of such stones on nearby areas that had been more sparsely vegetated had been turned over.

What made the stones turn? The roots of the grasses and wildflowers that had grown in the cracks of the pavement weren't strong enough to flip the stones, even if the vegetation were uprooted by strong wind, Haff argues. Human activity probably wasn't the culprit because the valley lies in a remote area and there weren't any footprints, vehicle tracks, or campfire remains.

Instead, Haff suspects, the stones had been flipped by rodents or birds rummaging for roots or seeds. In one instance, Haff observed a flock of more than 100 birds foraging among the dead weeds and later found a significant number of overturned rocks there.

If widespread enough, such disruptions of desert pavement could serve as long-lasting signs of even brief ecological changes, suggests Haff. Although the vegetation that triggered the purported feeding frenzies in the Greenwater Valley's desert pavements was ephemeral, the effects of foraging on the desert pavement have lingered much longer.

TANKS, A LOT The suddenly mobilized sand and dust that plagued Kuwait after the war 12 years ago—and still blot the landscape there today—were unleashed during a mere 6 months of military maneuvers. Now, imagine the dust that winds could loft from the U.S. Army's National Training Center, Fort Irwin's Rhode Island-size facility in the heart of the Mojave Desert in southern California. Ten months each year, the center hosts war games and other exercises involving heavy-infantry vehicles.

In places, a few decades of traffic have pounded the training center's grounds into a fine silt, just as if it had been exposed to centuries of natural weathering, says Jayne Belnap, a research ecologist at the U.S. Geological Survey in Moab, Utah. A lot of that loose material, which is calf-deep in spots, gets kicked up as dust. Elsewhere in the center, the soil has been packed to the point that rainfall doesn't infiltrate the surface, which increases runoff there and erosion from unpacked soils nearby. Also, the roots of desert plants often can't penetrate packed soils, and the plants therefore are slow to repopulate such areas.

The center is "like Kuwait on steroids," says Robert H. Webb, a hydrologist with the U.S. Geological Survey in Tucson. In severely compacted areas, it could take a century or so for natural geological processes, such as the expansion and contraction of clays, to restore just the upper 6 cm of soil to its previous consistency.

USGS studies of tank tracks at other Mojave Desert training areas used in the 1940s show that, even after more than 5 decades, soil density beneath the rut made by the single pass of a military tank is up to 6 percent higher than it is at a similar depth beneath undisturbed surfaces nearby. That difference may seem small, but investigators found that water seeps into the ground in the old tank tracks only half as quickly, on aver-

HAFF

age, as it does into untouched soil.

With large-scale field experiments, scientists might determine which restoration practices are effective, says Eric V. McDonald of the Desert Research Institute in Reno, Nev. He is now in the early stages of designing potential restoration projects for two Fort Irwin sites, each about the area of nine football fields. At one site, where recently disrupted desert pavement had been in place for the past 10,000 years, researchers will look for inexpensive ways to repair damaged portions of the surface, restore the vegetation, and perhaps recapture many of the original soil characteristics. Sensors embedded in the soil beneath revamped surfaces should reveal whether the temperature and soil moisture content there match those beneath pristine pavements nearby.

At another Fort Irwin site, a low-lying area where the desert pavement isn't yet fully formed, scientists will probably look at a different set of techniques, says McDonald. One possibility is to deposit a gravel veneer and spray on chemical treatments that penetrate several centimeters into the ground and bind soil particles together. Such treatments sometimes are used to control dust at construction sites and on unpaved roads.

In field trials that McDonald hopes to implement at a military test site in Arizona, he would apply various combinations of added gravel, soil binders, and other treatments to small plots. Results from these experiments could guide efforts to create new desert pavements at the Fort Irwin sites, he notes.

This proposed research might reveal that it's impossible to artificially restore desert pavement, says McDonald, "but at least we'd be looking at [the issue] in a scientific way."

U.S. GEOLOGICAL SURVEY

SCARRED FOR LIFE — Tank tracks from a military exercise in the early 1940s still blemish the Mojave Desert today.

The results of these inquiries could affect more than distant war-torn lands and military training grounds here at home. Even four-wheel-drive pickups driven by weekend thrill seekers can wreak desert havoc. Although lighter than tanks, the trucks exert about four times as much pavement-busting pressure on the ground as tanks do, because the area truck tires occupy is much smaller than the footprint of a tank tread. That means the actual pressure per given patch of ground is higher for the smaller vehicles.

The burgeoning populations of large cities throughout the U.S. Southwest are venturing into arid, environmentally sensitive lands in ever-increasing numbers, McDonald notes. Regardless of whether those folks cross the desert in four-wheel-drive trucks, dune buggies, or hiking boots, they typically don't tread lightly enough to leave desert pavement intact. If they're not careful, they could churn up dust that could make life downwind miserable for generations. ■

OF NOTE

BIOMEDICINE

Protein found central to ecstasy fever

Scientists have identified a protein contributing to the high fevers that are sometimes generated by 3,4-methylendioxymethamphetamin, the drug better known as ecstasy.

Debate about the stimulant intensified recently with the retraction of a study indicating that casual use of the drug kills brain cells and can be deadly (*SN: 10/4/03, p. 221*).

Scientists know that overdoses can cause a dramatic spike in body temperature, which sometimes leads to fatal organ failure. In the Nov. 27, 2003 *Nature*, researchers from Ohio Northern University in Ada and the National Heart, Lung, and Blood Institute in Bethesda, Md., report that mice lacking a molecule called uncoupling protein 3 (UCP-3) don't suffer fevers or die when given ecstasy. UCP-3, which is found in skeletal muscle, resembles other proteins that mammals and even some plants use to convert energy into heat (*SN: 12/13/03, p. 370*).

The investigators speculate that the actions of UCP-3 also contribute to the fevers brought on by other drugs, such as ephedrine and cocaine. Agents that dampen the protein's activity could be treatments for drug overdoses, they say. —J.T.

ASTRONOMY

Lunar finding doesn't hold water

Only a few years ago, planetary scientists were excited by reports that shady craters at the moon's poles might contain substantial amounts of ice. The hydrogen in frozen water could serve as rocket fuel for space explorers. But new radar findings may dampen earlier enthusiasm.

Using the 305-meter radio dish at Arecibo Observatory in Puerto Rico, researchers examined several craters at the moon's poles. Compared with lunar soil, which absorbs radar signals, ice would produce a strong radar reflection. In the Nov. 13, 2003 *Nature*, Donald B. Campbell of Cornell University and his colleagues report seeing no such reflection.

According to the team, the finding counters that of the lunar-orbiting Clementine spacecraft, which gathered radar reflections indicating that a south-pole crater could contain ice (*SN: 1/4/97, p. 11*). A spectrometer aboard another craft revealed that the poles are rich in hydrogen (*SN: 3/14/98, p. 166*).

It's still possible that amounts of ice too small to provide a clear radar signal lie within polar craters, says Paul Spudis of the Johns Hopkins Applied Physics Laboratory in Laurel, Md., who analyzed the 1994 Clementine data. The issue won't be settled, he says, until a lander is sent to regions suspected of harboring ice. —R.C

EARTH SCIENCE

Earth sometimes shivers beneath thick blankets of ice

New analyses of old seismic data have unveiled a previously unrecognized type of earthquake—quakes created by brief surges of massive glaciers.

When fault zones slip, they emit most of their stored energy as high-frequency ground motions, so that's the type of vibrations that scientists typically monitor to detect earthquakes, says Göran Ekström, a geophysicist at Harvard University. However, by using a data-processing technique that considers only low-frequency ground vibrations, he and his colleagues have discerned dozens of quakes of about magnitude 5 that aren't associated with any known fault zone. Instead, Ekström notes, they originated beneath large glaciers.

Between 1993 and 2002, seismometers detected 120 subglacial quakes along the east and west coasts of Greenland, 6 in Antarctica, and 1 in Alaska. The Antarctic quakes don't show a seasonal pattern, but most of those in Greenland occurred during July, August, and September. That's when sunshine can melt large volumes of glacial ice, says Ekström. If some of that fluid makes its way beneath a glacier, it could lubricate the ice stream and enable it to lurch forward.

The subglacial quake in Alaska occurred in September 1999, and seismometer data suggest that the magnitude 5.0 event lasted 30 to 60 seconds. The energy released corresponds to 10 cubic kilometers of ice surging 13 meters, the researchers say.

Seismologists haven't focused on earthquakes' low-frequency ground motions because those aren't the ones that cause damage. Also, researchers haven't directly observed subglacial quakes because the regions where they occur are so remote, says Ekström. —S.P.

EARTH SCIENCE

Alaska shook, mountains spoke

The largest inland earthquake to strike North America in more than a century shook south central Alaska on Nov. 3, 2002 (*SN: 11/16/02, p. 307*). Small pulses in atmospheric pressure detected in Fairbanks soon after the quake suggest that the magnitude 7.9 temblor literally moved mountains, briefly turning them into 3-kilometer-tall granite loudspeakers.

The quake began at a site along the Denali fault about 135 km south of Fairbanks. From there, the slippage sped toward the southeast along the fault at a rate of about 3.3 km per second, says geophysicist Charles R. Wilson of the University of Alaska in Fairbanks. At some spots along the total 320-km slippage, fault surfaces suddenly moved almost 9 meters past each other.

The first seismic waves from the quake arrived in Fairbanks about 27 seconds after the slippage began, says Wilson. About 12 minutes later, an array of sensitive microphones near the city began detecting minuscule variations in atmospheric pressure. During the following 10 minutes, the apparent source of this infrasound— pressure waves with frequencies below those that people can hear—gradually moved from the south to the southeast, tracking the movement of the fault rupture.

All the data suggest that the sudden motion of tall mountains in the Alaska Range, which lies along the Denali fault, disturbed the air and created the infrasonic pulses, says Wilson. —S.P.

SEISMOLOGY

Newfound fault may explain quakes

On the morning of Nov. 1, 1755, the thriving port city of Lisbon, Portugal, was devastated by three earthquakes, the tsunamis they triggered, and an ensuing fire. Tens of thousands of residents lost their lives. Now, tsunami simulations suggest that a newly discovered fault zone beneath the Atlantic Ocean could be the source of most of the seismic energy released that day.

Lisbon experienced the three temblors within 10 minutes, says Maria Ana Baptista, a geophysicist at the University of Lisbon. Scientists have long debated where those earthquakes originated because the two known fault zones beneath the ocean southwest of Portugal—the Guadalquivir Ridge and the Gorringe Bank faults—aren't long enough to have released the total seismic energy of that day's quakes.

Also, Baptista notes, the estimated arrival times for tsunamis generated by quakes along those faults don't match historical accounts of when the killer waves reached the port. Finally, researchers haven't found any evidence of large undersea landslides that could have triggered the tsunamis, so most scientists suspect that all three waves were generated by the earthquakes themselves.

Recent seismic surveys of the Atlantic seafloor east of Gibraltar suggest that there's a subduction zone where the African tectonic plate dips below the Eurasian plate. An earthquake there in which fault surfaces slipped about 20 meters—the sort of earthquake that might occur every 1,500 years or so—could have generated a magnitude 8.8 earthquake. That temblor, with smaller ones along the Guadalquivir Ridge and Gorringe Bank faults, could account for the size of the Lisbon quakes on the disastrous day in 1755, as well as the heights and arrival times of the tsunamis the quakes triggered, says Baptista. —S.P.

TECHNOLOGY

New technique dates glaze on desert rocks

Scientists have developed a quick, easy, portable, and nondestructive way to determine the age of desert varnish, the mysterious dark coating that slowly develops on rocks in many arid regions of the world (*see p. 11*).

Desert varnish is rich in iron oxides and manganese oxide—both possible products of biological processes—and contains varying amounts of clay, says Nicholas E. Pingitore Jr. of the University of Texas at El Paso. Researchers don't fully understand how desert varnish forms on exposed rock surfaces, but they agree that it does so exceedingly slowly. Ancient artists created petroglyphs scraping away the dark coating to reveal the lighter rocks beneath.

Data from many sites suggest that the iron and manganese oxides in desert varnish accumulate at a slow and relatively steady rate but that clay in the coating builds up sporadically. Using varnish samples of known ages, Pingitore and a colleague have developed an X-ray–fluorescence technique that measures the iron and manganese in desert varnish and thus indicates its age. Each measurement takes just 2 minutes.

Besides its possible use in dating petroglyphs, the technique could determine the age of ancient rock slides or to assess when ground motions along fault zones exposed fresh rock, says Pingitore. —S.P.

Books

A selection of new and notable books of scientific interest

THE DOCTORS' PLAGUE: Germs, Childbed Fever, and the Strange Story of Ignác Semmelweis

SHERWIN B. NULAND

Today, even young children know to wash their hands before they eat or after they go to the bathroom. In mid-19th-century Vienna, however, the idea of washing one's hands to stop the spread of disease was subversive. At that time, one of every six mothers in Europe died of abdominal infection within a few days of giving birth. Doctors had many suspicions about the cause of the disease they called childbed fever. Perhaps the pressure of the uterus on the intestines caused stasis of fecal material that was then absorbed into the veins. It never occurred to anyone that doctors spread the disease by working on cadavers and then, without a stop at the washbasin, delivering babies. A Hungarian physician named Ignác Semmelweis began to suspect that link and insisted that physicians wash their hands in a chemical solution before seeing each patient. Though Semmelweis might have become renowned as the founder of germ theory, he himself undermined any such recognition. In the same engaging style he employed in *How We Die*, Nuland evokes the medical and political climate of the time to tell Semmelweis' story and give him the credit Nuland argues that this forgotten physician deserves. ***Norton, 2003, 191 p., hardcover, $21.95.***

THE FEYNMAN LECTURES ON PHYSICS Volume 1: Quantum Mechanics Volume 2: Advanced Quantum Mechanics

RICHARD P. FEYNMAN

Richard P. Feynman was a Nobel prize–winning physicist who not only advanced quantum electrodynamics but was also famous for his outgoing personality and keen ability to impart complicated ideas to a lay audience. For more than 30 years, Feynman's three-volume *Lectures on Physics* has been a resource for students and scientists alike. These lectures were originally delivered to his physics students at Caltech and later fashioned by the author into a classic textbook. This set, comprising the first and second volumes of the complete audio-CD collection, contains 12 CDs of digitally remastered lectures, unabridged from the original recordings. The publisher has reorganized the talks for cohesiveness and convenience. Ranging from the basic principles of Newtonian physics to such formidable topics as Einstein's general theory of relativity, superconductivity, and quantum mechanics, Feynman's lectures stand as a monument of clear exposition and deep insight. ***Basic, 2003, 12 compact discs, $59.95.***

MAGIC UNIVERSE: The Oxford Guide to Modern Science

NIGEL CALDER

Science is ever changing and endless. Hence, Calder addresses the myriad directions of modern science. Although the stories he presents in this book are arranged A to Z, Calder argues that this isn't an encyclopedia. It's an organized way to present the spiderweb of scientific topics. Readers can open to any page and begin expanding their knowledge of subjects ranging from stellar dust to transgenic crops. Calder emphasizes interconnections of, for instance, atoms and stars, or of climate change, animals, and fossils. He doesn't stress cutting-edge research. Instead, he explores established theories and how they were molded into their present states. ***OUP, 2003, 756 p., hardcover, $40.00.***

PREHISTORIC PAST REVEALED: The Four-Billion-Year History of Life on Earth

DOUGLAS PALMER

In 200 pages, Palmer traces the 4-billion-year geological history of Earth, as revealed by research over the past two centuries. Loaded with photographs and illustrations, this book reads like the program of an elaborate museum exhibit. Images depict great fossil finds, maps, and time lines, and the text provides clear exposition about what these artifacts tell us about our past. Palmer also explains how scientists in this line of research are able to trace Earth's history from the petrified remains of shells and bones scattered through rock strata. Human history comes to light as Palmer surveys internationally famous fossil sites. Each site reveals another episode in the making of human beings. ***U CA Pr, 2003, 176 p., color photos/illus., hardcover, $29.95.***

THE UNIVERSAL BOOK OF ASTRONOMY: From the Andromeda Galaxy to the Zone of Avoidance

DAVID DARLING

You want to gawk at 150 hot young stars? Darling says look not to a Hollywood party but to the Arches cluster—stars at the center of the Milky Way crammed into a space roughly one light-year across. Darling is a noted astronomy writer who lets his readers in on the latest advances in this field. This is an encyclopedia of objects from every corner of the universe, but Darling paints an overall picture as well. Each of the 3,000 entries gives current information about a topic such as comets, asteroids, meteorites, moons, planets, constellations, nebulae, galaxies, microquasars, brown dwarfs, and dark energy but also tells a bit of the history of astronomy. Extensive cross-references direct readers to entries on related topics, which include astronomical societies, major observatories, and biographical information about key astronomers. ***Wiley, 2004, 570 p., color plates/b&w photos/illus., hardcover, $40.00.***

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LETTERS

Old, cold facts

That draining wetlands leads to a greater likelihood of frosts and freezes in southern Florida ("Frosty Florida: Spread of agriculture may promote freezes," *SN: 11/8/03, p. 292*) was noted nearly a century ago. In *The Commodore's Story* (1930, R. Munroe and V. Gilpin, Washburn), Ralph Monroe commented that "the 'frost line' moved spasmodically down the state as drainage decreased the water area and apparently influenced the temperature."

JAMES W. HAYMAN, SCOTTSMOOR, FLA.

Where were you?

"Forgetting to Remember: Emotion robs memory while reviving it" (*SN: 11/8/03, p. 293*) says that emotions can both decrease and enhance memories of specific events. It's been over 40 years since President John F. Kennedy was murdered, and I can remember being in my U.S. History class and hearing the news on the loudspeakers, as if it happened an hour ago. I have absolutely no memory of the days just prior to Kennedy's death.

SHARON LUEDTKE, LANHAM, MD.

Lively debate

In "Martian Invasion" (*SN: 11/8/03, p. 298*), the white cliffs of Dover are offered as a "notable example" of the precipitated carbonate deposits some have expected to find had Mars been wet and warm in the past. The Dover chalks are an unfortunate choice for comparison because they're composed primarily of the calcitic remains of microscopic marine phytoplankton. As most carbonate sediments on Earth are the result of direct or indirect biogenic activity, extensive examples of inorganically precipitated carbonate sediments will be hard to find.

K.M. TOWE, TENNILLE, GA.

Solution to "Science News Challenge"

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S M T W T F S

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Wide World Publishing/Tetra, 2003, 12" x 18", $10.95

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